# PATENT ABSTRACTS OF JAPAN

(11)Publication number : 09-129932
(43)Date of publication of applicati n : 16.05.1997

(51)Int.Cl. H01L 33/00

(21)Application numb r : 07-281170
(22)Date of filing : 30.10.1995

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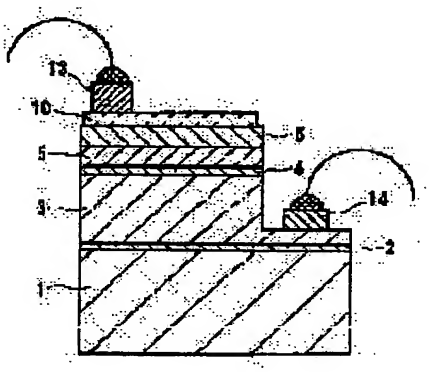
## (54) NITRIDE SEMICONDUCTOR LIGHT EMITTING ELEMENT

(57)Abstract:
PROBLEM TO BE SOLVED: To improve the light transmissivity of a nitride s miconductor light emitting element by forming a translucent electrode containing at least vanadium on almost the entire surface of the p-type layer of the light emitting element on which the p-type layer is formed as the outermost layer.
SOLUTION: After a buffer layer 2, an n-type contact layer 3, an active layer 4, a p-type clad layer 5, and a p-type contact layer 6 are successively grown on a sapphire substrate 1, a mask is formed in a prescribed shape on the surface of the topmost p-type GaN contact layer 6 and part of the contact layer 3 is exposed by etching the layers 4, 5, and 6. Then the mask is removed from the surface of the contact layer 6 and Pd is vapor- d posited to a film thickness of 30Å on almost the entire surface of the topmost GaN layer 6 as a p-electrode 10. The translucent electrode 10 c ntaining Pd transmits visible light, especially, visible light of purple to gre n color more than the conventional translucent electrode does. Th r fore. when the electrode 10 is formed on the surface of the p-type lay r 6, the light transmissivity of a nitride semiconductor light emitting lem nt can be improved.




LEGAL STATUS

| | |
|---|---|
| [Dat of request for examination] | 18.02.1998 |
| [Dat f sending the examiner's decision of rejection] | |
| [Kind of final disposal of application other than the xamin r's decision of rejection or application converted r gistration] | |
| [Dat of final disposal for application] | |
| [Patent number] | 3269070 |
| [Dat of registration] | 18.01.2002 |
| [Number of appeal against examiner's decision of rejection] | |
| [Dat of requesting appeal against examiner's decision of r jection] | |
| [Dat of extinction of right] | |

## DETAILED DESCRIPTION

[D tailed Description of the Invention]
[0001]
[Industrial Application] this invention relates to the electrode of the light emitting device which starts light emitting d vices, such as Light Emitting Diode to which it comes to carry out the laminating of the nitride semiconductor (InXAlYGa1-X-YN, 0 <=X, 0<=Y, X+Y<=1), especially by which p type nitride semiconductor layer was formed in the maximum front face.
[0002]
[Description of the Prior Art] Now, blue Light Emitting Diode and green Light Emitting Diode using the nitride semiconductor (InXAlYGa1-X-YN, 0 <=X, 0<=Y, X+Y<=1) are put in practical use. The fundamental structure of these Light Emitting Diodes is n type nitride semiconductor layer (it is hereafter called n layers.) which consists of n mold AlYGa1-YN (0<=Y<=1) on a transparent insulating substrate. The barrier layer which consists of InXGa1-XN (0< X<=1), and p type nitride semiconductor layer which consists of p mold AlZGa1-ZN (0<=Z<=1) (it is hereafter called p layers.) It has terrorism structure to the double by which the laminating was carried out to order. Since this Light Emitting Diode cannot take out n lectrode from a substrate side, it considers as the so-called flip chip form which takes out n electrode and p electrode from the same side side. A luminescence observation side side has many by which the electrode, i.e., p layers, side is mad the luminescence observation side, although it also becomes a side someday a substrate and electrode side, since th substrate is transparent.
[0003] In order to take out luminescence of a barrier layer outside, the electrode which consists of a metal of a translucency is prepared in p layers which become a luminescence observation side side. Moreover, we showed the light mitting device by which the metal electrode of a translucency was prepared in the front face of p layers in JP,6-314822,A. How v r, in the metal electrode of the conventional translucency, the permeability of the electrode to blue and green light was bad, and was not what it can still be satisfied [ with an external quantum efficiency ] of enough.
[0004] By the way, the electrode used for the light emitting device which consists of semiconductor materials, such as Light Emitting Diode, needs to obtain the semiconductor material and desirable ohmic contact, in order to reduce forward voltag . Also in Above Light Emitting Diode, desirable ohmic contact has been obtained by the electrode which contains Ti and aluminum in n layers, and the electrode which contains nickel and Au in p layers.
[0005] In addition, the tin oxide, indium oxide, and the zinc oxide are shown in JP,5-55631,A as an electrode material f rm d in a nitride semiconductor. However, the material shown in this official report is an electrode formed in the i (insulat r) type nitride semiconductor which doped acceptor impurity, and is not desirable ohmic ********** and th el ctrode formed in p layers. Moreover, although Ag, Au, Pt, Ir, Pd, Rh, etc. are stated to JP,5-315647,A as a desirabl l ctrode formed in p layers, only Au electrode is prepared in i layers of the light emitting device of not p type but MIS structure in fact.
[0006]
[Problem(s) to be Solved by the Invention] A crystal growth is a very difficult material and, as for p layers, it is more nearly actual than before that the physical properties are not yet solved well, either. Even if Light Emitting Diode which has p-n junction is realized, the electrode formed in p layers also has many points which should still be improved, p more layers and concordance are good and the electrode material excellent in many properties is called for. Moreover, improvement in an xt rnal quantum efficiency is desired in Light Emitting Diode. Therefore, the place made into the purpose of this invention is by offering the new electrode of p layers useful as a light emitting device to realize the light emitting device excellent in th external quantum efficiency.
[0007]
[M ans for Solving the Problem] The light emitting device of this invention is characterized by forming the electrode of the translucency which contains palladium (Pd) at least mostly on the whole surface of the front face of the p aforementioned lay rs in the nitride semiconductor light emitting device which comes to form p layers in the maximum front face.
[0008] Moreover, it is characterized by the aforementioned electrode containing at least a kind of metal chosen from the group which consists of the platinum (Pt), the rhodium (Rh), the ruthenium (Ru), the osmium (Os), the iridium (Ir), nickel (nickel), and gold (Au) other than Pd at least. These elements can maintain the translucency of an electrode, without spoiling the ohmic nature of Pd, even if it adds to Pd. In addition, the laminated structure which carried out the laminating of the thin film as electrode structure after adding is sufficient, and in the state where heat annealing of the laminated structure was carried out, and it was alloyed is sufficient, and it is good also as a state of an alloy from the beginning. Als in it, since th lectrod of a b nding pad and adh siv property of Au containing Au ar go d, it is v ry desirable.
[0009] Furth rm r , when making an el ctrod into a laminat d structur , it is still m r desirable that the sid which touches p typ lay r is Pd. By making Pd int the side which touch s p lay rs first, m st things for which ohmic nature is lost are lost.
[0010] 500A r l ss f things f r which a desirabl translucency is maintain d to th lumin scence wav length of a light mitting devic is still mor pr ferably p ssibl for the thickness of p lectr d form d n p layers in the light emitting d vic of this inventi n by adjusting to 200A r l ss. This thickness is the same also ab ut th cas where th r metals ar mad to c ntain b sides Pd, and can maintain a d sirabl translucency by making the total thickn ss f an electrod into 500A or l ss.

by 2-micromet r thickness, finally it heat-tr ats abov 400 d gr es C by the annealer, and an l ctrode is made to alloy.
[0024] The waf r which form d the lectrode in n type contact layer 3 and the p layer contact lay r 6 as m ntion d abov Cut in th shape of [ f 350 micrometer angle ] a chip, and silicon-on-sapphire sid 1 of the luminesc nce chip is past d up with a leadfram . When wire bond is carri d out by Au line, a mould is carried out by the epoxy r sin and it c nsiders as a Light Emitting Di de el ment, it sets t If(forward curr nt)20mA. It was 460nm in Vf(forward v ltag )3.4V and luminescenc wav length, and the radiant power output was higher than Light Emitting Diode of this structure which has p lectrode of the translucency containing conventi nal nickel and conventional Au about 30%.
[0025] In the [exampl 2] exampl 1, when the 100A laminating of 20A and the nickel was carried out for Pd to the p lectr d 10 and also the Light Emitting Di de el m nt was btained similarly, although it was Vf3.4V, in If20mA, th radiant pow r output d clined about about 15% under th influence of nick l.
[0026] In the [example 3] example 1, when the 100A laminating of 20A and the Au was carried out for Pd to the p electrode 10 and also the Light Emitting Diode element was obtained similarly, in If20mA, it was Vf3.4V. The radiant power output was almost quivalent to the thing of an example 2.
[0027] In the [example 4] example 1, when the 100A laminating of 20A and the Rh was carried out for Pd to the p electrode 10 and also the Light Emitting Diode element was obtained similarly, in If20mA, it was Vf3.5V. The radiant power output was almost quivalent to the thing of an example 2.
[0028] In the [example 5] example 1, when the 100A laminating of 20A and the Ru was carried out for Pd to the p electrode 10 and also the Light Emitting Diode element was obtained similarly, in If20mA, it was Vf3.5V. The radiant power output was almost quivalent to the thing of an example 2.
[0029] In the [example 6] example 1, when the 100A laminating of 20A and the Pt was carried out for Pd to the p electrod 10 and also the Light Emitting Diode element was obtained similarly, in If20mA, it was Vf3.5V. The radiant power output was almost equivalent to the thing of an example 2.
[0030] In the [example 7] example 1, when the 100A laminating of 20A and the Os was carried out for Pd to the p electrode 10 and also the Light Emitting Diode element was obtained similarly, in If20mA, it was Vf3.5V. The radiant power output was almost equivalent to the thing of an example 2.
[0031] In the [example 7] example 1, when the 100A laminating of 20A and the Ir was carried out for Pd to the p electrod 10 and also the Light Emitting Diode element was obtained similarly, in If20mA, it was Vf3.5V. The radiant power output was almost equivalent to the thing of an example 2.
[0032]
[Eff ct of the Invention] As explained above, the light emitting device of this invention can be formed in the front fac of p lay rs, and can take out luminescence of a barrier layer outside effectively. And since the electrode is excellent also in ohmic nature with p layers, Vf can realize a low practical light emitting device. When the light emitting device of this inv ntion is used for Light Emitting Diode devices, such as for example, a full color Light Emitting Diode display, a Light Emitting Diode signal, and the traffic information plotting board, a bright device can be realized by the low power and th utility value on the industry is size.

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[Translation done.]

(19)日本国特許庁(JP)　(12)公開特許公報（Ａ）　(11)特許出願公開番号

特開平９－１２９９３２

(43)公開日　平成9年(1997)5月16日

| (51)Int.Cl.[6] | 識別記号 | 庁内整理番号 | ＦＩ | | 技術表示箇所 |
|---|---|---|---|---|---|
| Ｈ０１Ｌ　33/00 | | | Ｈ０１Ｌ　33/00 | Ｅ | |
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審査請求　未請求　請求項の数３　ＯＬ　(全５頁)

(21)出願番号　特願平7-281170

(22)出願日　平成7年(1995)10月30日

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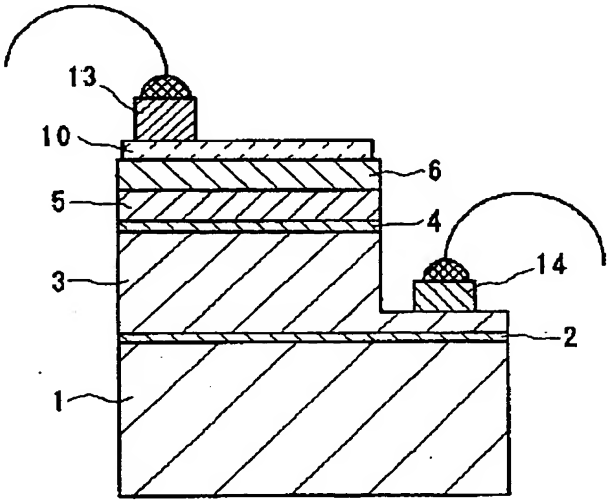
(54)【発明の名称】窒化物半導体発光素子

(57)【要約】
【目的】　発光素子として有用なｐ層の新規な電極を提供することにより、外部量子効率に優れた発光素子得る。
【構成】　ｐ型窒化物半導体層が最表面に形成されてなる窒化物半導体発光素子において、前記ｐ型窒化物半導体層の表面のほぼ全面に、少なくともパラジウム（Ｐｄ）を含む透光性の電極が形成されているので、透光性電極を通して発光が観測でき、外部量子効率が向上する。



を維持することが可能である。この膜厚はＰｄの他に他の金属を含有させた場合についても同様であり、電極の総膜厚を５００オングストローム以下とすることにより、好ましい透光性が維持できる。

【００１１】ｐ電極を形成するには蒸着、スパッタ等、通常の気相製膜装置を用いることができる。製膜装置により膜厚を制御して、前記のように５００オングストローム（０．０５μｍ）以下、さらに好ましくは２００オングストローム以下の膜厚にすることにより、好ましい透光性となり、発光素子の発光を透過する。なお透光性とは発光素子の発光波長を電極が透過するという意味であって、必ずしも無色透明を意味するものではない。

【００１２】本発明の発光素子はＭＯＶＰＥ（有機金属気相成長法）、ＨＤＶＰＥ（ハライド気相成長法）、ＭＢＥ（分子線気相成長法）、ＭＯＭＢＥ（有機金属分子線気相成長法）等の気相成長装置を用いて、基板上に窒化物半導体の結晶を成長、積層することで作成可能である。基板にはサファイア（$Al_2O_3$）、ＺｎＯ、スピネル（$MgAl_2O_4$）、ＳｉＣ、Ｓｉ、ＧａＮ等が用いられるが、サファイア、ＳｉＣが用いられることが多い。積層構造としては、基本的に基板の上にｎ層を成長させ、ｎ層の上にｐ層を積層して、ｐ層が最表面となるように積層して、この最表面のｐ層に電極を形成できる構造とする。この他、ｐ－ｉ－ｎ接合して、ｐ層が最表面とされた発光素子でもよい。ｎ型の窒化物半導体は、例えばＳｉ、Ｇｅ、Ｓｅ等のドナー不純物をドープすれば成長可能である。一方、ｐ型の窒化物半導体は、Ｍｇ、Ｚｎ等のII族元素、Ｃ等のアクセプター不純物を窒化物半導体中にドープすることにより成長可能である。例えば、ＭＯＶＰＥ法を用いてアクセプター不純物をドープした窒化物半導体を成長させると、成長後、何の処理をしなくともｐ型特性を示すものもあるが、好ましくは、４００℃以上でアニーリング処理を施すことにより、さらに好ましいｐ型特性を示すようになる。なおｐ型とは、例えばアクセプター不純物をドープした窒化物半導体で、抵抗率が$10^3\Omega\cdot cm$以下を示す半導体をいう。

【００１３】

【作用】Ｐｄを含む透光性の電極は、可視光、特に紫色～緑色領域にかけての透過率がＮｉとＡｕよりなる従来の透光性ｐ電極よりも優れている。従ってｐ層の表面に形成した場合に、窒化物半導体発光素子の光透過率が良くなるので、外部量子効率が向上する。しかも、オーミック性も非常に優れており、特にＰｄをｐ層と接する側に形成した場合、そのＰｄの上に他の金属薄膜を透光性の状態で形成しても、オーミック性を維持することができる。特にＰｔ、Ｒｈ、Ｒｕ、Ｏｓ、Ｉｒ、Ｎｉ、Ａｕ等の金属はＰｄと合金化しても、良好なオーミック性を維持できる。さらに、ｐ電極をｐ層のほぼ全面に形成してあるので、電流がｐ層全体に均一に広がり、局部的な電界集中が起こらず、活性層全体から均一な発光が得られる。

【００１４】図１はｐ層に形成した各種電極の電流電圧特性を示すグラフである。具体的に、ｐ層の上に次に述べる薄膜を形成した後、４００℃以上でアニールしてｐ電極を形成し、同一種類の電極同士の電流電圧特性を測定することにより、その電極のｐ層に対するオーミック性を調べたものである。また、図２は図１に示す透光性電極の透過率を示すグラフである。電極は次の通りである。

【００１５】Ａ：Ｐｄを４０オングストロームの膜厚で形成した透光性電極。

Ｂ：Ｎｉを６０オングストロームと、Ａｕを２００オングストロームの膜厚で順に積層形成した従来の透光性電極。

【００１６】図１に示すように、両方とも良好なオーミック性は示しているが、さらにＰｄはｐ層と抵抗が低く、非常に良好なオーミック性を示していることが分かる。

【００１７】また図２は各電極の透過率を示すものであるが、従来のＮｉ－Ａｕを含む電極（Ｂ）は窒化物半導体発光素子の発光の特徴である紫色～緑色領域にかけての透過率が悪い。これに対し、本発明の発光素子に係る電極Ａの透過率は、Ｂに比べて優れているので、発光素子の外部量子効率を向上させることができる。

【００１８】

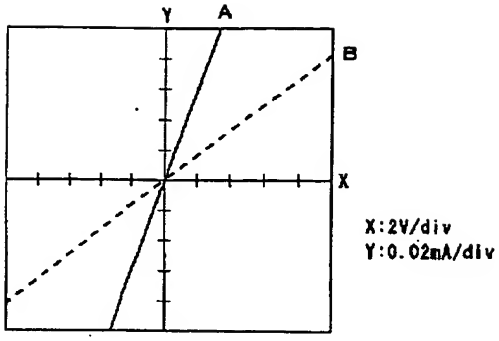
【実施例】以下、図面を基に本発明の発光素子の一実施例について説明する。図３は本発明の発光素子をｐ層の電極側から見た平面図であり、図４は図３の発光素子を図に示す一点鎖線で切断した際の構造を示す模式的な断面図である。

【００１９】［実施例１］ＭＯＶＰＥ反応装置を用い、２インチφのサファイア基板１の上にＧａＮよりなるバッファ層２を２００オングストローム、Ｓｉドープｎ型ＧａＮよりなるｎ型コンタクト層３を４μｍ、ノンドープ$In_{0.2}Ga_{0.8}N$よりなる単一量子井戸構造の活性層４を３０オングストローム、Ｍｇドープｐ型$Al_{0.1}Ga_{0.9}N$よりなるｐ型クラッド層５を０．２μｍ、Ｍｇドープｐ型ＧａＮよりなるｐ型コンタクト層６を０．５μｍの膜厚で順に成長させる。

【００２０】さらにウェーハーを反応容器内において、窒素雰囲気中で６００℃でアニーリングして、ｐ層５、６をさらに低抵抗化する。アニーリング後、ウェーハを反応容器から取り出し、最上層のｐ型ＧａＮの表面に所定の形状のマスクを形成し、エッチング装置でマスクの上からエッチングを行い、図２に示すようにｎ型コンタクト層３の一部を露出させる。

【００２１】次に、ｐ層の上のマスクを除去し、最上層のｐ型ＧａＮ層のほぼ全面に、ｐ電極１０として、Ｐｄを３０オングストロームの膜厚で蒸着する。蒸着後のＰｄ膜は明らかに透光性となっており、サファイア基板１

【図１】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A
B
X
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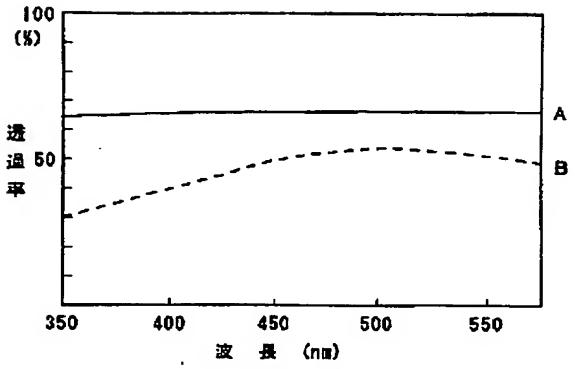
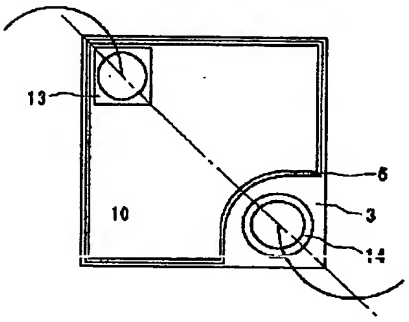
Y:0.02mA/div

【図２】


100
(%)
透過率
50
A
B
350
400
450
500
550
波長 (nm)

【図３】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6
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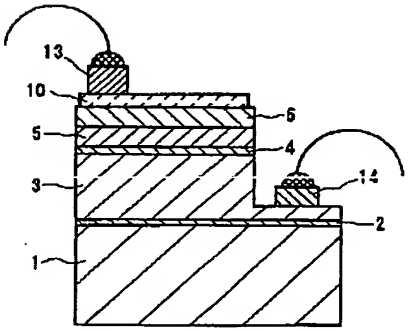
【図４】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